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The Biscuit Fire:

Management Options for Forest Regeneration, Fire and Insect Risk Reduction and Timber Salvage

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Executive Summary

Reflecting concerns about the aftermath of several fires in southwest Oregon in 2002, Commissioner Doug Robertson, on behalf of the Douglas County Board of Commissioners, requested that the Oregon State University (OSU) College of Forestry examine post-fire restoration considerations that would be influenced most strongly by action or inaction in the near term. The College was specifically requested to review the consequences of action or inaction on the following items as a function of 1-year, 3-year, and 5-year delays in action:

Forest and Rangeland Health

- Forest regeneration
  - likelihood of near- and long-term vegetative recovery to stand and landscape conditions with a desirable species composition and structure
  - habitat conditions in the near and long term for threatened and endangered species of native plants and animals
  - near- and long-term resilience and resistance of forest and rangelands to future disturbances, such as fire and storms
- Water quality as it relates to Clean Water Act standards and habitat for aquatic species
- Soil erosion effects on site fertility and on sediments deposited in streams
- Vulnerabilities to invasive species of plants and animals
- Potential impacts of effects of the fire on the ability of the federal agencies to achieve the objectives of the Northwest Forest Plan (NWFP) (FEMAT 1993, Tuchmann et al. 1996)
- Road system management

Economic Issues

- Risks related to future fires, insects, disease, or invasive species posed to adjoining property and residences by near- and long-term forest and rangeland conditions
- Timber salvage
  - revenues to counties produced or foregone
  - total value of marketable resources produced or foregone
- Local and regional capacity for future wildland and fire management
- Social quality of life, recreation programs, and aesthetics as impacted by treatment, delayed treatment, and no treatment. The impact of brush fields developing because of lack of treatment is a major concern.

Because time and resources were limited, this report addresses three of these considerations: forest regeneration, fire and insect risk reduction, and timber salvage.

The Biscuit Fire was selected as the study area primarily because written and electronic information was readily available. The Biscuit Fire began July 13, 2002. During the next 54 days, Biscuit burned approximately 400,000 acres within a perimeter surrounding 500,000 acres on the Siskiyou National Forest. Biscuit was the largest fire in recorded Oregon history and the nation's most expensive fire suppression effort of 2002, reportedly costing $150 million in federal and state funds.

Our analysis led us to ask (1) what kind of forest and other vegetation existed before the Biscuit Fire, (2) what exists now, in the immediate aftermath of the fires, and (3) what are the likely consequences and tradeoffs of allowing natural recovery, as contrasted to management interventions that hasten return of forest vegetation, capture some economic values, and reduce risks that future wildfires and insect outbreaks will impede recovery of ecosystems.

This report independently examines the same database available to the Rogue River/Siskiyou National Forests. Although there is much agreement with the data used by the Forests, this independent examination permits a perspective unconstrained by current administrative plans and policies.

Highlights of our findings include the following:

- Site conditions conducive to prompt reforestation of conifers will diminish rapidly as aggressive native shrubs and hardwoods resprout or regenerate along with invasive weed species.
- Reforestation, vegetation control, and removal of remaining dead and dying trees provide the main opportunities to reduce risk of recurring large-scale fires and shrub encroachment.
- Riparian habitat and habitat suitable for old-growth-dependent wildlife can benefit immensely from immediate actions to aid ecosystem recovery to forested conditions.
- The economic value of fire-killed timber will decline rapidly.
- Fire risk will increase if fuels are not managed and insects further damage fire-injured timber.
- When management to restore ecosystem health takes soils, water, fish and wildlife into account, adverse impacts can be minor compared with the long-term consequences of delayed action or lack of management interventions.
- The Biscuit fire presents area managers and the American people with a "once in a generation" opportunity to use such a large event to document the consequences and tradeoffs associated with letting nature take its course versus taking a variety of actions to influence future ecosystem conditions. This can be done by using large portions or all of the Kalmiopsis Wilderness Area as a "control" and non-wilderness areas as the "treatments."
- Biscuit provides an unparalleled opportunity to evaluate the efficacy of the federal NWFP as an ecological strategy to provide for late-successional forest resource values and uses in fire-prone ecosystems,

The following details of our analysis led to the above findings :

- We estimate that 10 billion board feet of conifer and hardwood was growing within the Biscuit Fire area on all land classes before the burn. Trees containing an estimated 4.2 billion board feet (conifer 83%, hardwood 17%) were killed by the fire, and an additional 0.8 billion board feet in fire-stressed trees are at risk of insect attack.

- Aggressive forest regeneration could accelerate the return to large-conifer-dominated forest ecosystems by 50 years or more and hasten return of forests to old-growth characteristics and values.
- Because grass, herbs, shrubs, and hardwoods will rapidly reoccupy much of the burned area, timely and aggressive reforestation is the only effective way to restore desired conifer forests on the most severely burned areas. Immediate action improves the odds of seedling survival and growth. The absence of such a reforestation program, in light of climate-change trends, will consign much of the burned area to shrub and hardwood cover for decades, perhaps centuries.
- The absence of an aggressive forest regeneration program will adversely affect late successional forest species. Particularly affected will be the federally listed northern spotted owl and other species inhabiting the mature conifer forests that received increased protection under the NWFP, especially in the intermittent and perennial stream zones.
- When planting is delayed beyond 2 years, the use of herbicides (approved by the Environmental Protection Agency) to control invasive species, native weeds, and highly competitive shrub species could reduce the cost of conifer establishment by up to two-thirds and improve the growth of young conifer stands. Herbicides could be a major factor in avoiding failure.
- Direct seeding, not feasible now because of restricted use of rodenticides and bird repellents, could greatly accelerate reforestation efforts in some remote areas where uniform stocking is not a goal.
- As much as 2 billion board feet of fire-killed timber, plus up to 0.5 billion additional board feet of insect-threatened fire-stressed timber, outside of the Kalmiopsis Wilderness may be economically accessible, depending on an array of policy decisions and funding. In 2002, 3.8 billion board feet were harvested from all forestlands in the state.
- The impact of carefully administered salvage logging on soil erosion is small and temporary when low impact ground skidders, cable systems, and helicopters are used. It is also small relative to the natural geological processes that characterize the region.

- The loss in value of dead trees from decay and insects is about 22% after the first year. At the end of 5 years, only the butt logs of the largest trees will have salvage value. The decline in economic value is even more rapid than the decay rate. By the summer of 2003, the loss of economic value is estimated to be in the tens of millions of dollars.
- Employment opportunities from salvaged trees average about 8–10 jobs per million board feet. Mill capacity in southwest Oregon and adjacent areas is probably sufficient to handle the potentially salvageable volume from Biscuit if market conditions are favorable. The net gain in regional employment would depend on how much fire-killed timber is substituted for green timber from private lands.
- The NWFP and associated laws, regulations, and current agency policies do not adequately address the natural dynamics of fire-prone ecosystems or the consequences of large, intense disturbances on desired future conditions of the forests.
- Recent salvage/restoration efforts in Missouri, Texas, and Arizona, as well as on the 1987 Silver Fire within the Biscuit Fire perimeter, provide important lessons. Aggressive action protected human health and safety in Missouri, protected endangered species and reduced insect risk in Texas, and salvaged economic values for Native Americans in Arizona. In Oregon, delayed timber salvage following the 1987 Silver Fire recovered some economic value, but Forest budgets at the time permitted only limited conifer restoration.

Table of Contents

Acknowledgments

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Introduction

Recent discussions between Hal Salwasser, Dean of the College of Forestry at Oregon State University (OSU), and the Douglas County Commissioners led to this examination of forest regeneration, timber salvage, and fire and insect risks on lands burned in 2002 in Southwest Oregon. Dean Salwasser formed a team to offer an independent, science-based review of management options and their consequences, that might be used in response to the effects of the Biscuit Fire on National Forest ecosystems. The team, led by Professor John Sessions (Department of Forest Engineering), also included Professors Mike Newton (emeritus, Department of Forest Science) and Robert Buckman (emeritus, Department of Forest Resources) and Research Assistant Jeff Hamann. They were charged to give special emphasis to those values that are at risk of deteriorating quickly and those long-term values that could be compromised by choices that range from various degrees of intervention to letting nature take its course. The Biscuit Fire was selected as the study area primarily because of the written and electronic information readily available from the Forest Service and other agencies.

This examination stems from a variety of environmental, economic, and social concerns in Southwest Oregon. Unemployment in these largely rural counties is high. The historically important forest products industry has declined in response to reduced timber supply from Federal lands. County revenues for school and road funding are precarious and are further threatened by loss of Federal funds. Many short-term environmental, health and safety issues are being addressed as part of the Burned Area Emergency Review (BAER) and the Fire Assessment of the Biscuit Fire (USDA Forest Service 2003). Some longer-term environmental questions are addressed here; others are beyond the scope of this brief assessment.

Against this background, the public, as expected, hold strongly polarized views on what should or should not be done with the burned areas, especially with respect to reforestation and timber salvage. This polarity can obscure rational consideration of potential compatibilities among various courses of action, including taking no action, and of weighing short-term versus long-term costs, benefits, and risks of those actions. Post-Biscuit issues are further complicated by the time-dependent nature of some management options and by the protracted National Environmental Policy Act (NEPA) and regulatory procedures that federal agencies must follow.

The issues surrounding what to do after Biscuit and other fires have already engaged political leaders at the local, state, and national level. It is not the intent of the College of Forestry to advocate for any particular policy related to value-driven choices; rather, it is to ask what scientific and analytic procedures can contribute to informing the inevitable choices and to be available, if requested, to address new or unanticipated questions.

Forest and rangeland ecosystems at any point in time or place are a constantly changing product of four interacting forces:

- natural climate, vegetation succession cycles, and natural selection
- large, recurring events, including the arrival and disappearance of species, that create new starting points for ecosystem growth and development
- small to medium-size events that alter trajectories of growth and development
- human actions that transform land cover, land use, local biota, or natural ecological processes

What we see on any landscape is a snapshot of the place at the time we observe it. A snapshot at any point in time, in the past or in the future, will never look like the current picture. Landscapes are always changing through the interaction of these four forces.

The first three forces have been at work forever and will continue to shape ecosystems and landscapes for as far into the future as we might envision. The fourth force has been present in the Pacific Northwest for only 10–20,000 years, as best we know. Until approximately 150 years ago, nature was largely free to respond to these four transforming forces. Then people changed that. First, newly arrived European-American settlers removed the Native Americans and their roles. Then they began altering landscapes more permanently to support their ever-changing lifestyles. Now we intervene to alter flood and fire cycles. We continue to harvest nature's bounty to support our communities and economies, but we do it at different scales of intensity and technology than did the Native Americans. And we reinvest in the land and its resources to ensure that future generations can reap the benefits that we enjoy. Reinvestment is often not characteristic when people first inhabit an area, but all societies that desire to sustain their well-being and that of the land they depend on must do so eventually.

Society has choices following large disturbances such as the Biscuit Fire, the Tillamook Burn, the 1996 floods, or the Mt. St. Helens eruption. We can step back and let nature proceed, or we can invest to shape a future different from what nature is likely to deliver. Often, we choose to do some of both. Nature will continue to function without human intervention. So our choice is solely about whether nature will deliver the outcomes we desire for future generations within the time frame we deem acceptable or whether we will intervene. Congress largely made that choice for us in Wilderness Preservation Areas; their future will be whatever nature delivers, and they require only the investments needed to minimize human imprints. This does not guarantee, however, that such areas will ever return after a disturbance such as the Biscuit Fire to what they were like before. Nature, under prevailing climates and biota, could recreate them entirely differently.

The choice for the future has not been made for all time in other areas, including those under management plans and policies that can be and periodically are altered in response to new goals, new knowledge, or changing technologies. This is the case outside the Kalmiopsis Wilderness Area in the Biscuit Fire area. Society and the managers of such places can select the "null" choice and let nature determine their future. Or they can select an "action" choice to influence how nature will shape their future. If they select an "action" choice, the task is to determine which actions will produce which desired outcomes, in which time frame, and how to pay for them. This is the context for post-fire ecosystem restoration in the Biscuit Fire: where not to act, where to act, what the actions should be, the time frame in which acting will be beneficial, and finding the resources to pay for management actions.

Approach

We partition this review into three broad categories, recognizing that they are highly interdependent: Forest Regeneration, Insect Infestation and Future Fires, and Timber Salvage. Within these three categories, we emphasize matters of urgency–where time weighs most heavily on the consequences of action or inaction. In broad outline, we ask

(1) What did vegetation in the Biscuit area look like before the Biscuit Fire, and what does it look like today?

(2) How will ecosystems in the Biscuit area likely evolve over the next 100 years with and without human investments to alter their course?

(3) What actions are available to choose among to influence a future different from what nature would deliver?

(4) What are the economic and environmental consequences, i.e., costs and benefits, of choices to invest or not to invest in actions to influence future landscapes?

Information sources are abundant but uneven in quality and detail. The Rogue River/Siskiyou National Forests have prepared a BAER and a detailed assessment of the fires (USDA Forest Service 2003). Extensive GIS and Continuous Vegetation Survey (CVS) information, satellite and aerial photo observations, and information from the U. S. Fish and Wildlife Service are also available. The large knowledge base from the 12-year Forestry Intensive Research (FIR) Program (Hobbs et al. 1992), aimed specifically at reforestation problems of southwest Oregon and conducted by OSU, the US Forest Service Pacific Northwest Research Station, and their cooperators, provides another important source of scientific information. Both OSU and the PNW Station are conducting significant research on regeneration, soil productivity, and watershed effects in the region. The Rogue River/Siskiyou National Forests have renewed monitoring on the 1987 Silver Fire and have initiated a similar program on the Biscuit Fire. Although we assessed the questions under review independently, we relied heavily on local Forest Service information.

Concerning the Biscuit Fire itself, questions broadly defined as environmental (including health and safety) received substantially more attention in the Assessment and BAER than did those concerning reforestation, salvage and fire and insect risks. Understandably, health and safety concerns and such matters as unstable roads, cut-and-fill stabilization, damaged bridges and culverts, repair of fire lines, and critical riparian needs deserve immediate attention. The Forest Service also substantially reviewed such questions as aquatic and terrestrial plant and animal resources, threatened and endangered species, noxious and invasive plants, and related issues. We view the treatment of those resource values by the Forest Service as more than adequate and, thus, not requiring additional review in this document.

Agency assessments, however, are limited in the in-depth studies and analyses required for questions that involve investing in actions to alter existing and future vegetative conditions—forest regeneration, timber salvage, and fuels and insect management—because they are more controversial and require extensive procedural steps. Staff of the Forests are working on these questions, but, as matters now stand, significant on-the-ground action is unlikely before the summer of 2004, perhaps even later. It is to these questions that we give most of our attention.

In this study, many assumptions were required. We have tried to be conservative, and we probably have underestimated the effects of the Biscuit Fire in defining our criteria for burned acres, salvageable volume, rates of wood deterioration, potential tree death from insect attack, and fuel buildup. Nevertheless, the values at risk are large.

Land use definitions, issues and reporting categories

Federal forestlands burned by the Biscuit Fire are managed for many different purposes. The four main categories we recognize in this study are Congressionally Reserved Lands (152,900 acres), Administratively Withdrawn Lands (64,100 acres), Late Successional Reserves (133,700 acres), and Matrix Lands (33,000 acres). The Congressionally Reserved Lands are primarily congressionally designated Wilderness. Administratively Withdrawn Lands include special wildlife, recreation, visual, and botanical areas the Forests have designated primarily for non-timber production. Late Successional Reserves are designated under the NWFP (FEMAT 1993, Tuchmann et al. 1996) to be developed and maintained for old forest characteristics. Matrix Lands are managed primarily for timber production. (Matrix usually refers to the dominant use designation for a landscape, within which are embedded less dominant use designations. “Matrix Lands” in the NWFP (FEMAT 1993, Tuchmann et al. 1996) are, in reality, the least prevalent use across the federal forest landscape; they are the special use areas within a matrix of reserved lands.) Riparian Reserves, a special designation along riparian areas within the Matrix Lands, are not tracked separately in this report.

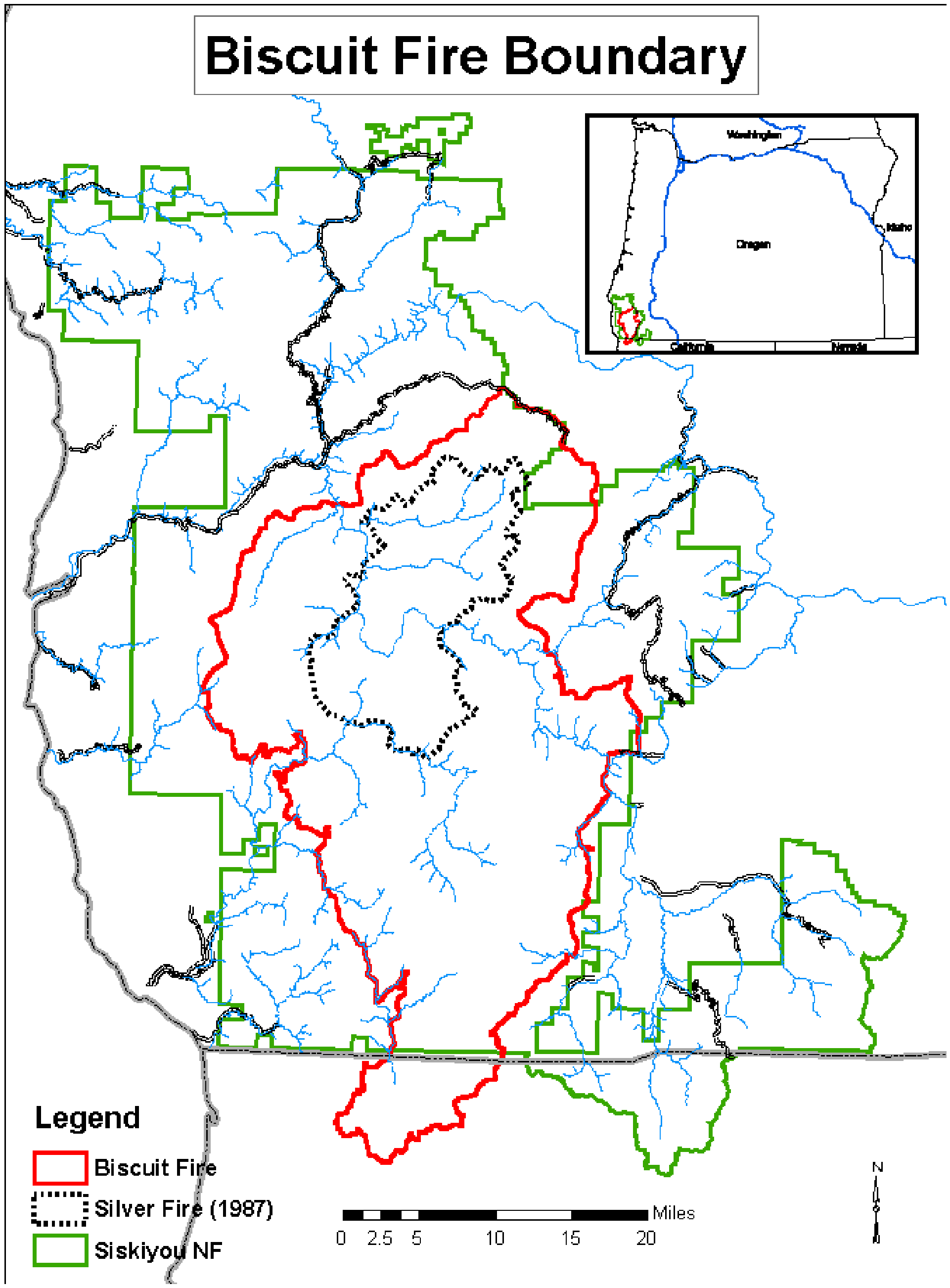

Figure 1. A map of the 2002 Biscuit Fire perimeter, including the 1987 Silver Fire perimeter. (Adapted from USDA Forest Service 2003)

Much of the Biscuit Fire (Figure 1) occurred in the Kalmiopsis Wilderness Area, in Administratively Withdrawn Areas, and in Late Successional Reserves. Elected and appointed officials are responsible for determining what lands should be restored and what restoration actions are appropriate in these areas, as well in Matrix Lands and Riparian Reserves. Our purpose here is to highlight restoration opportunities within the burned area and to provide information as to their magnitude and changes in quality over time. We categorize information by management-sensitive variables, including land allocation, ground slope, distance from road, and alternative regeneration techniques. For brevity, we often group categories.

Development of vegetation and spatial statistics

In order to develop a spatial vegetation database to provide stand attributes, timber volumes, and information on accessibility for pre-fire and post-fire conditions, we obtained tree and plot data from the USDA Forest Service Current Vegetation Survey (CVS). Two hundred and ten plots randomly selected from the study area were used to describe vegetation types for the area. A circular training area of 2 hectares was created around each of the CVS plot locations.

Landsat 5 Thematic Mapper (TM) images, obtained in 1995, were classified by using the sequential maximum *a posteriori* estimation (SMAP) (Schowengerdt 1997) with the GRASS software package (U.S. Army CERL 1993). The optimum index factor (OIF) was computed for all 20 combinations of the six TM bands (excluding the thermal band) to determine which three bands should be used to classify the images (Chavez et al. 1984). The three bands chosen for image classification (TM4, TM5, TM7) resulted in an OIF value of 47.08. The resulting classified image, which contained homogenous areas of similar vegetation characteristics, was then imported into ARC/INFO for further processing. Nonforest areas were masked out using the national land cover database (NLCD) grid for the area.

Polygons were created from the resulting classified grid and intersected with other polygon databases provided by the Siskiyou National Forest. Slope, aspect, and area within the top 20% of the slope for each of the stand polygons were computed and assigned to the stand polygons. The ridges were computed by using the TOPOTOOLS program available from the USDA Forest Service (www.reo.gov/digitalvisions). The stand polygons were then combined with land use allocation, soils and estimated burn severity (percent of canopy mortality) GIS layers. The polygons that were within 2 miles of a road were also developed for timber salvage and regeneration cost analysis.

Four site index values were assigned for nonserpentine-derived soils based on aspect and east/west designation. The two most western districts were projected at higher site index values than were the eastern districts. Growth-and-yield estimates were not done for the low productivity serpentine-derived soils. A high and a low range were used to simulate competing shrub conditions. The following 50-year King's site index values were used for projecting the basic 210 vegetation types, assuming free growing stands:

	Low range		High range	
Aspect	West side	East side	West side	East side
North	85	75	100	90
South	75	55	90	70

We used a post-fire Forest Service photo-interpreted classification of the percent of canopy mortality (USDA Forest Service 2003) to identify trees that were most likely killed by the fire and removed those trees from the tree lists. Basal area mortality was assumed to be related directly to percent canopy mortality. The midpoints from the Forest Service post-fire photo assessment canopy mortality categories were used to establish mortality levels. Trees were removed from the tree list in order of ascending diameter. These trees were then processed for decay rates to determine the amount of sound wood available for salvage within five years by using relationships from Lowell et al. (1992).

Additional mortality from stressed trees believed to have high insect infestation risk was also estimated using the results of a Forest post-fire survey (USDA Forest Service 2003). Risk to stressed trees was assumed to be concentrated in the low moderate to high moderate burned areas. Trees in unburned and lightly burned areas were assumed not to be fire-stressed. Trees in heavily burned areas were assumed to be either too few or too isolated to be included. Although the number and volume of trees at risk from insect attack were estimated, these trees were not removed from the tree lists for growth projections.

The basic 210 vegetation types were then expanded to account for the five levels of canopy mortality that determined the amount of direct fire-induced mortality and for the four site index values that resulted in 4200 stand types. The vegetation types were projected for 100 years by using the ORGANON Dynamic Linked Library (DLL) growth and yield model (Hann et al. 1997).

To estimate the decay of standing fire-killed trees and their contribution to down wood, fire-killed trees were passed from the ORGANON DLL to a snag-and-down-wood decay model (Mellen and Ager 1998) that produced estimates of standing fire-killed trees and down logs in various size classes over time. Although the Mellen and Ager model is calibrated for the Cascade Range, we felt it was the best model available.

The Biscuit Fire Forests–Prefire and Present

Geology and soils

The area of the Biscuit Fire is a geologic patchwork, mostly in the Klamath Province (Franklin and Dyrness 1973, Atzet et al. 1992). It is characterized by rough terrain, deeply incised valleys, and geologic strata that vary in resistance to erosion. The mountains and valleys result entirely from continuing tectonic uplift, accompanied by natural erosion associated with millions of years of weather, water, and fires. These processes continue today. The region has some of the highest rates of natural geologic erosion in the United States. Natural erosion on landscapes such as these overwhelms the effects of prudent land management practices.

Soils in the burned area can be loosely grouped into two categories, those that are derived from serpentine base rock and those that are not. The serpentine-derived soils are the most erosion prone. They are high in magnesium and low in calcium, and their water-holding capacity is low. Vegetation on these soils is sparse, and they are low productivity lands for conifer forests. About 25% of the soils within the Biscuit Fire perimeter are serpentine-derived. The remainder are derived primarily from sandstones and schists; their productivity for conifer forests is low to medium.

Forest vegetation

Pre-fire conditions

Within the Biscuit Fire, mature forests (>100 years) were predominantly composed of Douglas-fir, white fir, tanoak, Jeffrey pine, and Port-Orford-cedar with patches of western white pine, sugar pine, ponderosa pine, madrone and other species (Figure 2).

Figure 2. Prefire landscape view inside the Biscuit Fire area, Kalmiopsis Wilderness, looking west from Hayward Peak toward the Big Craggies. (Photo by Kevin Johnson)

Few acres reached great ages (>300 years) because of the history of frequent fires, and most of these older stands were on north slopes that do not burn as readily as stands on other aspects.

We estimate the pre-fire timber volume within the fire perimeter to have been about 10.0 billion board feet (Table 1). [To estimate pre-fire characteristics across the fire area, we reconstructed pre-fire vegetation by using a combination of remote sensing and ground plots.] Tree volume was 61% in Douglas-fir, 15% in pines, 7% in other conifers, and 17% in hardwoods.

Table 1. Estimates of combined conifer and hardwood volume (million board feet, gross scale, 32-foot log length basis) existing pre-fire on National Forest lands within the Biscuit Fire perimeter.

		Distance from road		
Land Allocation	Ground slope (%)	<2 miles	>2 miles	Total
Congressionally Reserved	0–30	59	161	220
	30–60	342	2323	2665
	60+	75	1030	1105
	Subtotal	476	3514	3990
Administratively Withdrawn	0–30	83	26	109
	30–60	528	368	896
	60+	203	184	387
	Subtotal	814	578	1392
Late Successional Reserves	0–30	309	43	352
	30–60	2008	433	2441
	60+	544	253	797
	Subtotal	2861	729	3590
Matrix	0–30	185	6	191
	30–60	700	31	731
	60+	61	6	67
	Subtotal	946	43	989
Total		**5097**	**4864**	**9961**

Current conditions

The Forest Service estimates that there are more dead conifer trees than live on two-thirds of the area burned within the fire perimeter (Figure 3) (Forest Service 2003). The remaining one-third of the area burned either less severely or not at all. Of the 100,000 acres where most or all trees survived the fire, many of the stands of surviving mature trees are on north-facing slopes. There are also stands of intermediate age resulting from a mosaic of fires from times past. Elsewhere, on about 345,000 acres, many of these kinds of stands were killed or severely burned by the Biscuit Fire.

Figure 3. Panoramic view of the Biscuit Fire, April 2003. Much of the 400,000 burned acres looks like this. (Photo by J. Sessions)

At least 25% of the canopy was killed on more than two-thirds (345,000 acres) of the 500,000-acre area (Table 2). Roughly 210,000 acres of that area is outside of the Kalmiopsis Wilderness Area. Of the area with greater than 50% canopy killed, 167,000 acres are outside the Wilderness Area. On nearly all of the burned area, root systems of burned hardwoods and shrubs survived, along with large accumulations of their viable seeds. These are in place, ready to sprout and dominate post-fire forests. Many of these hardwood and shrub species are also highly flammable after a few years of regrowth.

Table 2. Estimate of acres burned, derived from USDA Forest Service (2003) photo interpretation intersected with digital terrain model attributes and Siskiyou Forest land use allocations. The estimates do not include private lands; non-forest, unburned; and lightly burned National Forest land within the fire perimeter; and BLM forest lands. Estimates deviate somewhat from USDA Forest Service sources (USDA 2003), primarily in the interpretation of unburned and lightly burned forest. The Forest Service reports 460,000 acres of burned forest land.

Land Allocation	Ground slope (%)	Canopy killed (%)					Total
		1–10	10–25	25–50	50–75	75+	
Congressionally Reserved	0–0	-	900	1,000	2,100	8,600	12,600
	30–60	1,300	11,200	12,700	11,500	63,200	99,900
	60+	400	7,300	5,600	4,800	22,300	40,400
	Subtotal	1,700	19,400	19,300	18,400	94,100	152,900
Administratively Withdrawn	0–30	-	200	600	1,300	5,900	8,000
	30–60	100	2,300	5,800	8,500	24,100	40,800
	60+	-	700	2,600	3,900	8,100	15,300
	Subtotal	100	3,200	9,000	13,700	38,100	64,100
Late Successional Reserves	0–30	-	800	2,100	1,700	11,100	15,700
	30–60	300	7,400	20,500	14,600	49,000	91,800
	60+	100	2,100	7,100	4,900	12,000	26,200
	Subtotal	400	10,300	29,700	21,200	72,100	133,700
Matrix	0–30	100	1,100	1,300	800	2,600	5,900
	30–60	100	2,400	3,600	5,800	12,600	24,500
	60+	-	100	300	800	1,400	2,600
	Subtotal	200	3,600	5,200	7,400	16,600	33,000
Total		**2,400**	**36,500**	**63,200**	**60,700**	**220,900**	**383,700**

We estimate that the fire killed approximately 4 billion board feet of tree biomass, 40% of the pre-fire volume within the fire perimeter (Table 3). We estimate that average standing live-tree biomass volume on the area (excluding low productivity serpentine soils) has declined from a pre-fire average of 26 thousand board feet/acre (85% conifer) to 14 thousand board feet/acre, with large areas occupied solely by dead trees. Hardwoods and small diameter whitewoods would have little salvage value.

Table 3. Estimate of combined conifer and hardwood fire-killed timber (million board feet, gross scale, 32-foot log length basis) on National Forest lands within the Biscuit Fire perimeter.

Land Allocation	Ground slope (%)	Distance from road <2 miles	Distance from road >2 miles	Total
Congressionally Reserved	0–30	29	83	112
	30–60	165	910	1075
	60+	40	396	436
	Subtotal	234	1389	1623
Administratively Withdrawn	0–30	47	15	62
	30–60	267	166	433
	60+	100	90	190
	Subtotal	414	271	685
Late Successional Reserves	0–30	157	22	179
	30–60	847	195	1042
	60+	219	109	328
	Subtotal	1223	326	1549
Matrix	0–30	57	3	60
	30–60	286	22	308
	60+	29	5	34
	Subtotal	372	30	402
Total		**2243**	**2016**	**4259**

What are the options?

- To supplement natural ecological processes with investments to regenerate with conifer species, at stocking rates and with supplemental management actions that will yield future ecosystem conditions different from those likely to occur under natural processes, *or* to let nature take its course
- To salvage some fire-killed timber as an integral part of restoring ecosystems to desired future conditions with respect to species composition, diversity, and resilience or resistance to fires, storms, insects, or invasive weeds, *or* to let all dead and dying trees stay on the landscape. (Because of the burned area within the Kalmiopsis Wilderness Area, it is not possible to salvage all, or even most, of the fire-killed trees.)
- To reduce fire and insect risk, *or* to let natural processes continue

- To generate funds that would help pay for prudent and necessary investments by salvaging some resources from the area, *or* to pay for all needed work from general tax funds appropriated by Congress
- To obtain the necessary clearance to use herbicides and low conifer stocking levels to regenerate the largest number of acres with the greatest probability of success, *or* to attempt mechanical control of vegetation competing with conifers, *or* not to attempt to control competing vegetation

Forest wildlife

Pre-fire wildlife habitat

The Forest Service estimates that 300 wildlife species meet at least part of their yearly needs on the Rogue River/Siskiyou National Forests (USDA Forest Service 2003). Three of these species are federally listed as threatened and endangered: the bald eagle, the marbled murrelet, and the northern spotted owl.

Habitat for the spotted owl is the most significant consideration. About 25% of the 202 known spotted owl activity centers on the Siskiyou National Forest are within the Biscuit Fire area. The only known bald eagle nest site on the Siskiyou National Forest is outside the Biscuit area. There were pre-fire bald eagle sightings along the Chetco and the Illinois Rivers. About 30% of the critical habitat for the marbled murrelet on the Siskiyou National Forest is in the Biscuit area, but only a relatively small portion of that on the western side of the Biscuit area is within its known range.

Over 460 miles of streams and rivers within the Biscuit fire area contain both resident and anadromous salmonids. Several species are at risk, with the federally listed coho salmon being the most sensitive. Monitoring of fish habitat after the 1987 Silver Fire suggests that adverse effects from that 97,000-acre fire were not as severe as expected.

Current wildlife habitat

Of the three federally listed species, the spotted owl was the most severely impacted by the fire. Twenty-three of the 40 “functional home ranges” (containing at least 40% suitable home range habitat) of the spotted owl within the area were transformed to “nonfunctional” habitat in the fire; an estimated 75,000 to 80,000 acres of nesting habitat were rendered unsuitable (Forest

Service 2003). The Forest Service also estimates that dispersal habitat for the spotted owl was reduced, connections of dispersal habitats with "functional home range habitats" were severely disrupted, and east-west dispersal corridors remain only in limited areas within the fire perimeter. Marbled murrelet habitat was less seriously disturbed, with less than 20,000 acres of critical habitat impacted. Bald eagle habitat may have improved because of an increase in dead trees to nest and perch in.

Crown canopy was greatly reduced on nearly 17,000 acres of riparian habitat, potentially resulting in higher stream temperatures in summer and diminishing habitat quality for fish. Whether these areas should be reforested promptly, with vulnerable sideslopes stabilized and damaged stream channels repaired, depends on preparation of site-specific work plans.

Figure 4. Late Successional Reserve outside Onion Camp. Grasses in foreground are sprouting from hay bales dropped by helicopter to prevent soil erosion. (Photo by J. Sessions, May 2003)

Biscuit poses a key policy question on the intent of the NWFP (FEMAT 1993, Tuchmann et al. 1996) in areas designated to function as mature and old-growth forests (i.e., Late Successional Reserves) (Figure 4). Under the NWFP, Late Successional Reserves are intended to sustain a regionally connected network of older forests. After fire in Late Successional Reserves, are managers to let the forests develop to whatever future condition natural processes bring them to, or are they to invest in the return of younger forests to their intended late successional status as quickly as possible?

What are the options?

- For recovery of old-growth dependent fish and wildlife habitat
- For recovery of riparian zones
- For deforested Late Successional Reserves to return to mature conifer condition

In the following sections, we explore consequences of natural processes for forest development after fire and options for speeding forest regeneration, reducing the risks for future fire and insect attacks, and salvaging fire-killed timber.

Forest Regeneration

Forest regeneration in southwestern Oregon is among the most difficult situations in the state, aggravated by hot dry summers and often formidable herb, grass, shrub, and hardwood competition that seriously impedes the recovery of conifers in both tree size and abundance. Because of the difficulties in natural and artificial conifer regeneration, Oregon State University, the USFS PNW Station, the USDI Bureau of Land Management (BLM), and industry cooperators have been studying regeneration in southwest Oregon for more than 20 years (Hobbs et al. 1992). Although the results of the studies have varied, the findings are clear: (1) conifer establishment in southwestern Oregon is difficult, (2) lessons have been learned, (3) success is possible, and (4) ignoring the lessons invites delayed restoration and costly failure. The results of this research are summarized below. We assume in this report that the goal of artificial regeneration is to establish 200 young conifer trees "free to grow" (still living after 5 years) on each planted acre on all lands for which there is a decision to restock conifers. Two hundred trees per acre (of which 20% can be hardwoods) is the minimum tree stocking standard required on private lands under the Oregon Department of Forestry (ODF) Forest Practice Administrative Rules (Oregon Department of Forestry 2000) for average or higher productivity sites in western Oregon. Lower productivity sites have a goal of 125 trees per acre, free to grow.

Natural regeneration is permitted under the ODF Rules, but the State Forester must approve a written plan. That plan must provide the State Forester with sufficient certainty that there is a high probability that the purpose of the reforestation rules will be achieved. Oregon Forest Practices Act rules do not permit significant delays in reforestation on cutover lands on state and private lands. The State Forester may grant an extension for stands destroyed by wildfire, but the landowner, using recognized stand establishment methods, is required to achieve the required stocking standards within a time prescribed by the State Forester (Oregon Department of Forestry 2000). This is primarily an acknowledgment that regeneration becomes far more difficult once competing vegetation cover becomes established. Although federal lands are not subject to the same rules as private lands, we believe the ODF Rules are a useful standard for comparison. In this study, we do not consider artificial regeneration on the very low productivity serpentine soils.

Natural conifer recovery

If natural recovery of Biscuit ecosystems is the choice selected, it will be a slow and uncertain process, with shrub fields the likely future vegetation in many, or even most areas where conifer forest occurred before the fires. Over large areas of the Biscuit Fire, there are now no live conifer trees; hence seed availability is limited, a condition that will impede natural development to future conifer forest.

Competition

The Forest Service estimates that both natural and artificial conifer regeneration will be hampered by aggressive shrub and hardwood species that could delay conifer dominance for decades. Following the 1987 Silver Fire, which burned within the perimeter of the Biscuit Fire, shrub and hardwood growth created dense stands averaging nearly 20 feet high before they were reburned last summer. FIR Program data, updated recently, shows severe reduction in conifer growth from uncontrolled shrubs (Newton, Harrington, and Cole, 2003, in preparation).

By far, the most significant problem facing young conifer regeneration in the region is competing vegetation. With limited amounts of soil moisture, competition from woody and herbaceous vegetation greatly reduces the survival and growth of conifers (Gratkowski 1961 and 1978, Minore 1978, Williamson and Minore 1978, Stein 1981, Strothman and Roy 1984, Stein 1986, Walstad et al. 1987). Information from Hobbs and Wearstler (1985), Hughes et al. (1987), and Hughes et al. (1990) indicates that shrub stands reach high competitive vigor earlier than do conifer stands and that shrub species can rapidly occupy a site. Harrington and Tappeiner (1997) reported that, while survival of Douglas-fir differed little among initial abundances of tanoak, differences in growth became increasingly larger with decreasing percentage of initial tanoak cover.

Climate

Exacerbating this competitive situation is a warming climate. Much of the forest that burned in Biscuit was established during the waning years of the Little Ice Age. Current and likely future climates are more favorable to root-sprouting shrubs than when the burned forests originated (Tom Atzet, personal communication, 2003).

Time to recovery

In the absence of human assistance, we estimate that the larger conifer trees (>18 inches diameter) that provide much of the character of mature forest and most of the habitat for old-growth-dependent wildlife will take much longer to grow. On many sites, it will take 50 years or more to supplement the surviving larger trees, even with prompt regeneration, and up to 100 years to approach pre-fire conditions for 18-inch or larger trees. Without planting and subsequent shrub control, it could take more than 100 years to create future forests that are anything like the pre-fire forests

Human-aided conifer regeneration

Seeding or planting can hasten forest recovery after fires, but is most effective if implemented immediately. Delays will result in some stands failing or in increased costs of replanting. Most stands, even if successfully established, will require maintenance, either by costly manual release or by herbicides, to promote growth and retain stocking levels.

Aerial seeding

Approval to use aerial seeding techniques for forest trees, while not currently a realistic option for the Biscuit Fire because of lack of approved bird and rodent repellents, is a potentially powerful tool for rehabilitation after future fires. For example, more than 100,000 acres was seeded aerially in the highly successful Tillamook reforestation effort (Fick and Martin 1992). If necessary, research could be initiated to find acceptable techniques. If approved, of course, a large and geographically suitable seed supply would be needed. Direct seeding is the only method of reforestation capable of dealing quickly with thousands of acres in need of reforestation following fire, especially many acres that are some distance from existing roads. The National Forest System and Forest Service Research should soon revisit this question.

Seedling choices

Planting is feasible after salvage operations, on previously planted sites killed by fire, and other accessible areas. If an accelerated artificial regeneration program is adopted, immediate attention to arrangements for seed collection and contracts with large nurseries is needed in order to provide for intensive reforestation. Containerized seedlings (plugs) can be available for use in winter 2004-5 if ordered soon.

Nurseries can grow a variety of seedling types (Owston et al. 1992); however, they are not all equal in hardiness or growth rates, even within species. Large seedlings are better able to compete with other vegetation, but require an extra year in the nursery to reach a certain size. Often this is a good investment and permits planting fewer trees, hence raising overall costs relatively little. Container (plug)+1 or 1+1 transplants are now the standard for state and private organizations planting large areas where there is a reasonable threat of shrub competition or where maximum yield is an objective. These grow more rapidly than smaller stock types do, but require 1 year either in a container or in a nursery seedbed, followed by one year in a transplant bed (plug+1 or 1+1). The smaller 2+0 bare-root seedlings (2 years in a nursery seedbed) are much less costly than the transplants and containerized stock, but consistency in survival and growth are lower. The smaller stock is most adaptable to north slopes and deep soils, especially where shrub threats are minimal. They are helpful in stretching budgets where survival is good. One can save roughly $100/acre by substituting 2+0 seedlings for containerized trees or transplants of equal or greater size, but survival and growth results will not be as good when competing vegetation develops.

Combating non-native tree diseases

Conifer regeneration of the Biscuit also presents opportunities to decrease long term impacts of two extremely virulent non-native tree diseases associated with three minor, but important, conifers; sugar pine, western white pine, and Port-Orford-cedar. Although sugar pine and western white pine with resistance to white pine blister rust (caused by the fungus *Cronartium ribicola*) and Port-Orford-cedar with resistance to Port-Orford-cedar root disease (caused by the water mold *Phytophthora lateralis*) are available, they can be established on sites within the Biscuit Fire only if they are planted. Naturally seeded five-needle pines have little resistance to blister rust, and naturally seeded Port-Orford-cedars have almost no resistance to Port-Orford-cedar root disease. Including some resistant five-needle pine, Port-Orford-cedars, or both with other tree species on appropriate sites in a tree planting program would contribute to maintaining ecologically valuable tree species in diverse conifer stands in the fire-affected area. The area influenced by the Biscuit Fire includes about 20% of the entire natural range of Port-Orford-cedar and is also an important area for five-needle pines (Don Goheen, personal communication, July 2, 2003).

Planting on shrub-dominated sites

Planting conifers in shrub-dominated sites even 1 or 2 years after a fire commonly leads to failure or extremely poor growth. Even the best nursery-grown stock is affected by competition during the first few years after planting; initially high levels of herbaceous and shrub cover can increase seedling mortality and reduce growth (Roy 1981, Barrett 1982, Oliver 1984, Tappeiner et al. 1984, Peterson et al. 1988, Tesch and Hobbs 1989, White and Newton 1989, Harrington and Tappeiner 1997). Capo-Arteaga and Newton (1991) observed that five species of pine, including ponderosa and sugar pine, were established satisfactorily near the Rogue River if shrub and associated herbaceous species were controlled completely before planting. Success in planting beneath untreated shrubs as short as 2 feet tall led to extremely poor results, especially on south slopes.

The tools capable of reducing competition on tens of thousands of acres are limited. Prescribed fire cannot be used to prepare sites when shrubs are too small to provide adequate fuel. Personnel and budget are inadequate to provide effective manual or mechanical control; success of these techniques in improving either survival or growth is at best limited, as evidenced by observations on grass-dominated sites near Myrtle Creek and in shrub-dominated sites at other southwest Oregon locations. There are many examples of hand or mechanical shrub removal on federal lands, but none can be compared with treatments using chemicals because federal courts would not permit herbicide experiments on federal lands after a 1983 court injunction.

Stand maintenance

Once a site is initially reforested, the seedlings benefit tremendously from vegetation management (protection from shrub encroachment) for several years to ensure their survival, and to ensure fastest possible growth (Figure 4). This is illustrated by the four reforestation experiments from the FIR Program that continue to be measured (Newton, Harrington, and Cole, in preparation). Even when planting was completed immediately after a fire, failure to control shrubs in the first 2 years afterward reduced tree growth by 75%, substantially delaying attainment of tree sizes desired for late successional wildlife habitat. These differences would increase still more if the hardwoods had 1 or more years to develop before planting. Thorough site preparation will substantially reduce needs for release and improve growth and survival.

The four regeneration studies cited above involve more than 1600 trees that have been monitored continuously for 23 years. The growth of conifers on sites where tanoak and madrone sprouts were removed soon after planting is more than four times that on sites where tanoak and madrone are uncontrolled. These study sites are representative of the more productive areas in the Biscuit Fire (Newton, Harrington, and Cole, in preparation). They reveal the potential to shorten the time needed to reach mature forest conditions greatly. Without treatment, we estimate the diameter growth rates might be one-half or less and the time to comparable size would at least double. These study sites also showed that many species of subordinate shrubs and herbs persist through an array of reforestation procedures, so long-term diversity is not necessarily decreased.

The Newton, Harrington, and Cole experiments reflect the range of outcomes—from very poor growth to the maximum achievable—that can be expected from a forest site that has been denuded recently. The pine sites were mechanically cleared first, yet chemicals were needed to suppress manzanita soon after planting. Similarly, fire was used for site preparation on one madrone and two tanoak plots, yet stump sprouting allowed shrubs to begin reoccupying the sites within 2 years, at which time herbicides were applied to release planted Douglas-fir. Both tanoak sites resulted from clearcutting mature stands and broadcast burning for site preparation. Control of tanoak sprouts greatly increased conifer tree growth. In each example, naturally occurring shrubs were capable of severely reducing conifer growth without follow-up control.

Atzet et al. (1992) summarized a series of reforestation experiments from the FIR Program and from Forest Service experiments in northern California. These short-term studies recorded a growth reduction of up to 45% from failure to control competition. It is noteworthy that the longer term experiments from the FIR Program showed roughly a four-fold increase in growth rate over the entire 23-year period when shrubs were completely removed. This suggests that earlier short-term FIR results from young plantations seriously underestimated the importance of competing shrubs over the long-term life of a stand in this region.

Figure 5 illustrates the difficulties in stand establishment and maintenance on southwestern Oregon sites following the 1994 Hull Mountain Fire. The 7-year-old plantation on private land had vegetation management using herbicides and is free to grow. The adjacent plantation on federal land has been replanted at least once, has been released mechanically and is suppressed under brush. The private plantation investment including vegetation management is approximately $400 per acre; the federal investment is approximately $1200 per acre (Ken Cummings, chief forester, Boise Cascade Western Oregon Region, personal communication, May 23, 2003). The federal land will sustain higher diversity of common wildlife species associated with shrubs, herbs, and snags, while the private land will eventually have higher diversity of species associated with conifer forests.

Figure 5. Young plantation on private land (background, left) and plantation on federal land (right foreground) near Gold Hill, Oregon, established following the 1994 Hull Mountain Fire. Private plantation received vegetation management using herbicides; federal plantation has had mechanical release. (Photo by J. Sessions, October 2002).

The herbicide dilemma

Herbicides are efficient and cost-effective tools for control of aggressive and highly flammable shrubs and hardwoods, but the safety and effectiveness of their use have been controversial for decades. EPA and state policies permit the use of certain herbicides in forests, and they have been widely used on private and non-Federal public lands. Herbicides have been largely unavailable to the Forest Service in Oregon and Washington as the result of mediated court settlements in 1988 and 1989. The magnitude and severity of shrub competition in southwest Oregon (Figure 5), along with the hazards and ineffectiveness of manual vegetation management methods, merits a thoughtful re-examination of this policy for ecological, operational, and safety reasons.

Regeneration investments following the 1987 Silver Fire largely failed because of lack of funding for costly manual and mechanical treatments to control competing shrubs and hardwoods. There are outstanding side-by-side comparisons in southwestern Oregon of conifer plantations established on private lands after fires, with herbicides used for establishment and stand maintenance, with plantations receiving no herbicide treatments on federal land (e.g., as shown in Figure 5). On the private lands, vigorous conifers are free to grow; on the adjacent federal lands, struggling conifers are dwarfed by shrubs. On the federal land, fewer conifers will survive; those that do will require many more years to attain the size of those on the private land. In the meantime, fire control in shrub fields and among snag fuels will be more difficult on the federal lands, and the chance for conifers to survive future fire will be lower there. The choices available and their likely outcomes are clear.

Herbicides are the safest and most cost-effective tools available today for management of competing vegetation (Newton and Dost 1984). They do not visually impact the landscape, if applied when shrubs are small, nor do they cause illness or injury to work crews (Note records of Oregon's Pesticides and Analytical Response Center (PARC), Oregon Department of Human Services, the state agency responsible for investigating pesticide-related incidents that have suspected health or environmental effects.) Herbicides are used regularly by the forest industry and State of Oregon; average area treated is roughly 100,000 acres per year. Most applications are by helicopter. This set of tools has helped achieve high growth rates and stocking levels on over 90% of the forest industry land in western Oregon. There is a wealth of information on safety and efficacy that is unmatched by manual or mechanical methods (Newton and Dost 1984). The national forests of California have been using these products on thousands of acres per year since the federal injunction was lifted there.

In furtherance of the mediated court settlement in Region 6, the Forest Service now has an accepted EIS for the use of herbicides in vegetation management. Herbicides of several kinds are available in quantity on short notice. Products capable of controlling grass (atrazine or hexazinone), manzanitas, canyon liveoak or madrone (2,4-D), deerbrush and other deciduous shrubs (glyphosate) or tanoak and ceanothus (triclopyr) are all registered for use in forests. None of these is a restricted-use product. All can be used to release seedlings or for site preparation.

None poses measurable risks to fish or water quality if used according to the rules of the Oregon Forest Practices Act and at EPA approved rates (Newton and Norgren 1977, Newton et al. 1984, Newton and Dost 1984, Walstad and Dost 1984, ODF 1997, Felsot 1998).

Risk analysis for nonchemical tools will be difficult to do on an equally reliable basis with risk analysis for herbicides because there are far more data for the many herbicide uses than for mechanical or manual means. Indeed, the manual treatments are known to be extremely hazardous, causing major and minor injuries, not counting exposure to chemicals in 2-cycle engine exhaust. Moreover, there is little long-term evidence of efficacy of the nonchemical shrub controls to compensate for their high frequency of injuries. Delay in initiating the process of approval of these tools will result in increased costs and frustration in achieving successful reforestation.

Vegetation control on a large scale will be essential for decreasing risk of repeated fires. Maintenance of fuel breaks requires breaks in the continuity of fuel near the ground. Such areas must have trees widely enough spaced so that the crowns will not propagate a fire. Between the trees, shrubs must be controlled so that the accumulation of dry fuel will not cause explosive spread. Some of these fuel breaks will be needed in areas currently inaccessible by road. They will be the only defense against repeated large, intense fires in those areas. The data on the risk and impact of various vegetation- and fuel-control methods are clear. The effectiveness of herbicides over other methods is so large that reexamination of current policies could provide substantial restoration benefits.

Costs of regeneration

As an outgrowth of the FIR Program and related regeneration studies in the Northwest, Newton and Lavender (unpublished) have estimated (1) the initial cost of a variety of regeneration options, (2) the declining probability of success related to time, and (3) the differences of success on north versus south facing slopes (Table 4). Federal administrative costs are likely to be higher than for private forests, but the relative relationships between methods and delay of regeneration should remain valid.

Table 4. Cost of reforestation practices in establishing 200 trees per acre free to grow, and probability of success when beginning in years shown, on north and south slopes, Biscuit Fire sites.

			Probability of success, by year of establishment and slope									
			2004		2005		2006		2007		2008	
	Practice[1]	$/acre	N	S	N	S	N	S	N	S	N	S
a)	Aerial seed	$100	50	20	40	10	20	5	10	5	0	0
b)	Seed/bait	115	70	25	45	15	30	5	20	10	20	10
c)	Plant plugs	200	80	60	70	50	40	30	20	10	20	10
d)	Planting plugs+1	220	85	70	75	60	60	40	40	20	30	10
e)	Planting 2+0	130	75	65	65	55	50	25	30	15	20	10
f)	Plant plugs+SP[2]	268	80	70	80	70	75	60	70	50	65	55
g)	Plant plugs+1+SP[2]	288	90	80	85	75	80	65	80	65	80	65
h)	(f) plus release	315	80	70	80	70	80	65	80	65	80	65
i)	(g) plus release	335	90	80	85	70	85	70	85	70	85	70
j)	(e + SP[2])+ release	245	85	75	80	60	80	55	80	55	70	50

[1]Practices are as follows:

a) Aerial seeding entails 0.5 lb Douglas-fir seed, treated with malachite green, seed @ $180/lb, application at $10/acre (see discussion, Aerial Seeding section)
b) Seeding plus prior baiting with 1 lb/ac oats treated with 0.75% chlorophacinone @ $5/lb and $10/acre application.
c) Planting plug 615 container seedlings at $0.45 ea plus $0.55 labor x 200 trees per acre
d) Planting plug + 1 transplants at $0.45/tree, plus $0.65 each for labor
e) Planting 2 + 0 seedlings at $0.20/tree, plus $0.45 for labor
f) Planting plugs, plus chemical site preparation
g) Planting transplants, plus chemical site preparation
h) Planting plugs, plus site prep and release with atrazine 2,4-D
i) Planting transplants, plus site prep and release
j) Plant 2 + 0 seedlings, plus site prep and release

[2]Site preparation (SP) with 1.5 lb/ac hexazinone plus 2 lb/acre 2,4-D plus $25/acre application cost

Table 5. Estimated regeneration cost (dollars per acre) to successfully establish 200 conifer trees per acre considering initial cost, probability of success (Table 4) and cost of restocking failures. Bold italic values show the most cost-effective method for year of establishment. Cost effectiveness considers only tree survival, not substantial costs of later controlling shrub competition (see Stand Maintenance section).

	North slope				South slope			
Regeneration method	2004	2005	2006	2007	2004	2005	2006	2007
Plant plugs	***250***	***286***	667	1000	333	400	1000	2000
Plant plugs +1	259	293	***367***	733	***314***	***367***	550	2200
Plant plugs + chemical prep	335	335	357	383	383	383	447	536
Plant plugs +1+ chemical prep	320	339	360	***360***	360	384	***443***	***443***
Plant plugs + 1 + chemical prep + chemical release	372	394	394	394	419	479	479	479

Rogue River/Siskiyou National Forest managers (USDA Forest Service 2003) estimate reforestation costs at $1,000/acre, using current practices that do not involve use of herbicides (Forest Service administrative costs may be somewhat higher than for private owners). We estimate that aggressive use of the most promising techniques, including planting only 200 trees per acre, could reduce these costs by up to two-thirds. Table 5 considers cost per acre to re-establish conifer forests by year of planting, including probability of failure and cost of restocking to achieve success by slope. The most cost-effective method for stand establishment will depend on year of initiation.

Table 6. Estimated cost (million dollars) of artificial regeneration by planting 225,000 acres with best techniques, including herbicides when needed, or without herbicides.

	2004		2005		2006		2007	
Land allocation	<2 mi	>2mi	<2mi	>2 mi	<2 mi	>2 mi	<2 mi	>2mi
Congressionally Reserved (87,400 ac)								
Best	2.5	20.3	2.8	23.5	3.5	28.7	3.5	28.9
Without herbicides	2.5	20.3	2.8	23.5	4.0	33.4	13.6	111.3
Administratively Withdrawn (30,800 ac)								
Best	4.0	2.9	4.6	3.4	5.6	4.0	5.7	3.2
Without herbicides	4.0	2.9	4.6	3.4	6.6	4.7	22.0	15.6
Late Successional Reserves (85,600 ac)								
Best	12.4	4.4	14.4	5.2	17.6	6.2	17.7	6.4
Without herbicides	12.4	4.4	14.4	5.2	20.2	7.2	64.4	22.8
Matrix (20,800 ac)								
Best	3.9	0.3	4.6	0.3	5.6	0.4	5.6	0.4
Without herbicides	3.9	0.3	4.6	0.3	6.5	0.4	21.5	1.6
All (224,600 ac)								
Best	22.8	27.9	26.4	32.4	32.3	39.3	32.5	38.9
Without herbicides	22.8	27.9	26.4	32.4	37.3	45.7	121.5	151.3

Note: Does not include cost of regenerating 127,000 acres of serpentine soils that burned nor stands on non-serpentine soils that had less than 25% canopy mortality. Derived using area estimates from Table 2 and cost estimates from Table 5. Acres to be regenerated are assumed proportional to percent canopy mortality. Unit costs for planting acres at less than 2 miles from a road are from Table 5. Planting costs at distances greater than 2 miles are assumed to be 30% higher than Table 5.

Three things stand out from an examination of regeneration costs: (1) the most cost-efficient method of establishing conifers is immediate regeneration; (2) planting delays beyond 2005 can substantially increase costs through poor survival and high restocking costs if weed control is not adequate; (3) when delays are unavoidable, herbicides for site preparation and release will dramatically reduce costs of establishment over other reforestation options.

Size of the job

The Rogue River/Siskiyou National Forests Assessment (USDA Forest Service 2003) anticipates a reforestation program of about 31,000 acres. There are substantial opportunities to enlarge that reforestation effort, depending on rehabilitation strategies adopted by the Forests, goals for the Late Successional Reserves, and the availability of funds (Table 6). If Wilderness and serpentine soils outside of Wilderness were eliminated from potential reforestation sites, for example, and those areas with 25% or more scorched canopy were reforested, more than 137,000 acres would be candidates for restorative treatment toward mature, conifer forest. Even this estimate of area available for reforestation may be conservative because of classification of unburned areas.

Conclusions

Forest recovery for the spotted owl and other late successional species habitat in the absence of an aggressive reforestation program will be very slow. The Forest Service estimates that recovery of suitable owl-nesting habitat will take 160 years or longer in some areas because of delayed establishment and shrub competition (USDA Forest Service 2003). If there is prompt regeneration with trees free to grow, our projections indicate that nesting habitat might be produced in 80 years. Dispersal habitat recovery will be more rapid, but still depends on having sufficient tree cover. With prompt and effective regeneration and shrub control, some trees will exceed 18 inches in diameter in less than 50 years.

Years of research and experience in southwest Oregon show that

- Without artificial regeneration, the restoration of mature conifer forests may be delayed 50 to 100 years.
- Shrubs are serious competitors. Unless conifers are planted within the first 2 years following the burn, costs to establish desired stocking levels will double or triple, especially on south slopes. After 2 years, costs go up and survival decreases dramatically without vegetation management.
- In order to minimize the time to grow large-diameter conifers, shrub and hardwood control is essential. Without stand maintenance, desired habitat conditions may not be achieved, or at best will take a long time.
- Herbicides provide the most cost-effective method, by far, for containing costs and for providing site resources for restoring large conifer trees.
- While not practical for use on the Biscuit Fire at this late date, aerial seeding could be a valuable tool for rapidly establishing conifers on remote sites.

Insect Infestation and Future Fires

In the following section, we estimate the potential tree-death from insect attacks on fire-injured trees and the contributions to heavy fuels from these trees.

Insect infestation risks

Primary tree-killing insects, in general, do not attack dead trees, but they can kill green timber, particularly weakened trees. Green trees weakened by fire lose their ability to repel and survive insect attacks (Lowell et al. 1992, Edmonds et al. 2000). Bark beetles often kill many trees that might otherwise survive (Furniss 1965, Miller and Keen 1960) Insect and disease buildup can follow fire by killing fire-stressed (weakened) trees, creating additional snags and accelerating the development of fine fuels that create high rates of fire spread. If the insect buildup is large, adjacent unburned forests can be threatened (Furniss 1941).

In order to estimate the additional mortality from fire-stressed trees, we used the results of a post-fire survey (USDA Forest Service 2003) that provided probability of infestation by species and tree diameter. Risk to stressed trees was assumed to be concentrated in the low-moderate to high- moderate burned areas. Trees in unburned and lightly burned areas were assumed not to be fire-stressed. Trees in heavily burned areas were assumed to be either too few or too isolated to be included. Using this procedure, we estimate that stressed trees containing approximately 0.8 billion board feet of wood volume could die from insect attack in moderately burned areas (Table 7).

Table 7. Projections of mortality (million board feet, gross scale, 32-foot log length basis) from insect attack in fire-stressed trees, excluding very severely burned and lightly burned areas.

Land allocation	Douglas-fir	Pines	Other conifers	Total
Congressionally Reserved	203	17	15	235
Administratively Withdrawn	117	9	10	136
Late Successional Reserves	336	24	25	385
Matrix	75	5	9	89
Total	**731**	**55**	**59**	**845**

Many fire-injured, but still live, trees are infested and killed by bark beetles and woodborers within 5 years of the burn. Trees often die from insect infestation for up to 5 years; the largest numbers of fire-stressed trees are likely to be infested in the year after the fire and to exhibit dead foliage either at the end of that year or the spring of the subsequent year. Remaining live trees are also threatened by insects. There is the risk that, as insect populations build in the fire-stressed trees, the insects will leave the stressed trees to attack healthy green trees both inside and outside the burned area, leading to even higher fuel loadings. To reduce fire risk, trees under insect attack should be identified and removed, preferably when insect eggs and larvae are still in the trees. Researchers from the Rogue River/Siskiyou National Forests are monitoring the insect build-up, but action may be required even before monitoring is completed.

Heavy fuels and fire potential

The adage "lightning never strikes twice in the same place" is not true. Lightning frequency tends to be higher in certain areas, such as southwestern Oregon. Although we do not know when fires will start, we do know what conditions create fire hazards. These conditions include (1) availability of snags that are easily ignited and, when combined with wind, can spot fires up to 1 mile away; (2) forest litter (fine fuels) and shrubs that provide opportunities for rapid fire spread; (3) down wood derived from decaying dead trees that contributes to high-intensity fires ; (4) tree canopies that extend to the ground, providing fuel ladders to the tree crowns; (5) dense forest canopies that provide conditions for spread of crown fire; and (6) lack of access that can delay or prevent suppression. All of these contribute greatly to the difficulty in developing control strategies for new fires.

The Silver Burn and the Biscuit Fire

Sometimes fires occur during favorable weather conditions (low wind) and fire effects are not severe. In 1987, the Silver Fire in southwest Oregon was relatively mild, with only 12% burning at high intensity, 33% at medium intensity and 54% at low intensity (Kormier 1995). After the fire, about 6,000 acres were salvaged, reducing snag availability. About 3,000 acres were replanted. The Biscuit Fire at Florence Creek started in the area affected by the 1987 Silver Burn. Although the shrub-dominated Silver Burn area reburned in 2002, the fire was not as intense there as anticipated. Favorable fire weather and the salvage of some fire-killed timber in

1989–1990, combined with still-standing snags that had not yet had sufficient time to contribute down wood to the forest floor, probably moderated the 2002 fire effects. On other parts of the Biscuit area, the effects of the fire were much more severe.

Current conditions and future estimates

The forest has an average of more than 160 fire-killed trees per acre. These trees will fall over time and create small and large logs that, while providing habitat for many different species and slowly returning organic matter to soils, also will fuel the intensity of future fires. We estimated the number of standing dead trees (snags) per acre and the logs on the ground that would be derived from the dead trees as they fall and/or decay (down wood) in the Biscuit area. To do so, we combined the Forest Service photo-interpreted canopy mortality estimates with our vegetation overlay in order to identify the numbers of trees by diameter class and species that were killed by the Biscuit Fire. These dead trees were then entered into the Mellen and Ager (1998) snag decay model and their conditions were projected over time. We also added to the fire-killed trees those still living trees that would be expected to naturally die over the next 100 years.

We estimate that high numbers of snags will persist for several decades (Table 8) and that down wood accumulations on the forest floor will grow as snags fall and/or deteriorate (Table 9), reaching maximum levels in 40 years and remaining at those levels for several decades. The numbers of snags and amount of down wood will be higher in more severely burned areas and lower in less severely burned areas, but are indicative of the trend. Significant portions of dead and dying trees in Biscuit will leave the landscape prone to large, intense wildfires for at least 60 years into the future, further jeopardizing any potential for the forest to return to late successional conditions.

Table 8. Projected average number of standing dead trees (snags) per acre within the Biscuit Fire Perimeter on National Forest lands not considering contributions from pre-fire snags, epidemic insect attack, salvage, or future fires.[1]

	Diameter class (dbh, inches)				
Year	<12	12–18	18–24	24+	Total
2005	122	22	10	11	165
2010	95	14	6	6	121
2020	66	11	5	5	87
2030	40	7	4	5	56
2040	9	4	3	4	20
2050	6	3	3	4	16
2060	4	3	2	4	13
2070	3	3	2	4	12
2080	8	2	2	4	16
2090	6	2	2	4	14
2100	5	2	2	4	13

[1]Snag numbers include recruitment from living trees that are projected to die “naturally” over the coming decades.

Table 9. Projected average down wood volume (cubic feet per acre) within the Biscuit Fire Perimeter not considering contributions from pre-fire dead trees, epidemic insect attack, salvage, or future fires.[1]

	Log Diameter (inch)					
Year	3 to 6	6 to 12	12 to 18	18 to 24	24 plus	Total
2010	67	350	208	101	74	800
2020	75	427	283	219	250	1254
2030	82	511	407	310	420	1730
2040	86	540	465	372	519	1982
2050	65	552	496	455	632	2200
2060	52	387	434	454	704	2031
2070	52	270	398	463	789	1972
2080	23	241	369	408	704	1745
2090	26	234	351	375	685	1671
2100	26	222	338	346	660	1592

[1]Down wood includes recruitment from living trees that are projected to die naturally over the coming decades.

Conclusions

We know that insect attack of fire-injured trees is highly likely over the coming 2 to 5 years. In addition, we conclude that

- there is a high probability that fire-injured trees containing over 0.8 billion board feet will be infested by insects
- trees killed by insects will add to the fuel load
- increased insect populations in fire-injured trees could spread to adjacent green trees.

The added risk of fire starts in areas with heavy fuel loads from insect-damaged trees and down wood is not precisely predictable; however, if fires do start the adverse consequences are magnified:

- fire control strategies will be much more difficult
- threats to adjacent unburned areas will increase.

Finally, reburns in these areas will have a devastating impact on existing regeneration and seed sources that would otherwise renew the forest once again, as both new seedlings and seed sources will be reduced or eliminated.

Goals for Future Forests

Questions surrounding management options and choices for the Biscuit Fire revolve around collective societal goals for future forests and on weighing relative risks, benefits, and costs, not only of action, but of inaction. Where society and managers choose to let nature deliver the future landscapes and ecosystems, timber salvage is not only unnecessary, it would be counter-productive. This issue was raised most prominently 8 years ago, in a report by Beschta et al. (1995). In their report, Beschta et al. developed a number of conclusions and recommendations, one of which indicated that there "is no ecological need for immediate intervention on the post-fire landscape." If the goal is to let natural processes dominate, then there may well be no compelling ecological reason for salvage logging or any other human intervention in post-fire landscapes.

If, on the other hand, the goal is to deliver a future forest different from that which nature alone will deliver—particularly in light of the unique landscape characteristics of the Biscuit area in southwest Oregon—and to generate revenues to help pay for planting seedlings and other restoration activities on sites for which both natural and artificial reforestation is difficult, intervention may be warranted and salvage logging may be a legitimate option. Most of the forest lands within the Biscuit Fire area are already designated to be managed for old forest conditions and, as such, have an important place on the Oregon landscape, not only for wildlife, but for Oregonians and visitors alike. Beschta et al. (1995) did not evaluate opportunities for intervention to hasten forest regrowth or restoration on forest lands such as the Biscuit area that contain areas permanently set aside and widely valued for non-timber purposes such as wildlife habitat and recreational experiences in a mature forest.

Since the Beschta et al. (1995) report was published, other scientists, including Everett (1995) and Ice (Ice and Beschta 1999), have provided differing perspectives. Not only has the scientific knowledge base increased over the years, but our understanding of forest management, including the use of alternative methods on ecologically sensitive sites, has also greatly improved. Researchers have found there is enormous variability in both the effects of natural processes and the consequences of human-caused intervention on watersheds (McIver and Starr 2001, Fitzgerald 2002, Ice 2003). For example, from the research studies with unlogged controls reviewed by McIver and Starr, there is evidence showing that human intervention can reduce adverse watershed impacts, be largely neutral, or aggravate problems.

Fortunately, some of the most direct evidence has and still is coming from monitoring the Silver Fire complex (97,000 acres), which occurred in 1987 (in an area within the boundaries of the later Biscuit Fire). Here, a detailed monitoring plan was prepared in 1990 to track fuel reduction, salvage logging, and other remedial activities. It was partially implemented until 1995 (Kormeier 1995). The 1995 monitoring report concludes: “the lack of adverse effects from salvage logging is attributed to protection of riparian areas, improved road construction practices, and minimizing disturbance through the use of helicopter logging.” Researchers from the Rogue River/Siskiyou National Forests are now revisiting the Silver Fire to evaluate the consequences of both natural processes and remedial practices.

Timber Salvage

If the goal is to restore mature conifer forests on the Biscuit landscape quickly, timber salvage, carefully done, can be useful ecologically, economically, and socially. Ecologically it is useful to reduce future fuel loads and reduce potential additional tree death from insect attack, as well as to help hasten the regrowth and recovery of the forest. Economically it is useful by providing a potential source of funds for forest restoration, reducing the costs of future fire suppression, and making future helicopter stand-maintenance operations feasible. Timber salvage also holds the potential to provide a temporary source of extra revenues that could be used immediately to help fund schools or other public programs and services that have suffered under the current state budget crisis. Returns from salvage of fire-killed timber and fire-injured timber at high risk of insect attack in the Biscuit area could yield $100 million or more dollars, depending on the scope and timing of the salvage. Socially, timber salvage and subsequent forest regeneration is useful by providing resources for local employment in the short term and by enhancing recreation opportunities on these landscapes in the long term through forest restoration.

Timber salvage removes some standing fire-killed trees that will decay and fall over time, each tree adding fuels for future fires. It can reduce large log fuel loads by 50% or more while retaining the rest in the forest to provide habitat and wood debris to the forest floor and as a source of large wood in streams. Although timber salvage routinely concentrates on the recovery of usable timber values, it also affects future forest conditions by providing a source of income to finance restoration and to improve the ability to prepare sites and to maintain stands. For example, the construction of fire lines though snag patches is unsafe and is avoided; however, the strategic removal of fire-killed trees permits access by fire crews to fight future fires and also makes effective aerial operations possible. Consideration should be given to grouping dead trees important for wildlife in patches or lines that consider the safety and effectiveness of future forest operations.

Costs and time constraints

The fixed and variable costs of harvest are a particularly important consideration in timber salvage because of time constraints due to timber deterioration. As timber deterioration commences, there is a smaller economic base over which to spread the fixed costs of harvest such as necessary road improvements, equipment move-in, and setup. In addition, the cost of moving one ton of low value wood is the same as the cost of moving one ton of high value wood. For low-impact, high-cost systems such as helicopter logging, the window of opportunity for cost-effective salvage closes quickly.

The forest has an average of more than 160 fire-killed trees per acre, currently worth, in aggregate, several hundred million dollars (Table 8). Of the trees containing 10.0 billion board feet of wood volume that existed on all land allocations prior to the fire (Table 1), we estimate that trees containing approximately 4.2 billion board feet were killed by the fire (Table 3). Of these, trees containing about 3.6 billion board feet were conifers (Table 10) and trees containing about 0.6 billion board feet were hardwoods. The volume of wood in the fire-killed trees is roughly equivalent to the total estimated Oregon harvest volume on all of its 28 million forested acres for last year. We estimate fire-stressed conifers containing an additional 0.8 billion board feet are at high risk of insect attack in the near future (Table 7). Past experience (Kimmy and Furniss 1943, Lowell et al. 1992) indicates that the recovery value of fire-killed timber will decrease as trees deteriorate from checking, fungal decay, and woodborer activity. Based on data in Lowell et al. (1992), we estimate that approximately 22% of the fire-killed volume that existed immediately after the fire will be lost during the first year (Table 10) and by the fifth year, only volume in the lower logs of the larger trees will have economic value. With the exception of some low-volume species, such as Port-Orford-cedar, Douglas-fir are the most resistant to decay, whereas the white woods and pines are the least resistant; larger trees are more resistant to decay than are small diameter trees. By the summer of 2003, we estimate that the economic loss due to timber deterioration will already be in the tens of millions of dollars.

Table 10. Estimate of fire-killed volume of conifers, million board feet, gross scale, 32-foot log length basis, after deductions for deterioration by species group by year.

Year	Douglas-fir	Pines	Other Conifers	Total Conifers
2002	2610	642	299	3551
2003	2182	341	221	2744
2004	1831	295	90	2216
2005	1440	251	69	1760
2006	1149	232	46	1427
2007	908	210	26	1144

Soil erosion: Crucial considerations

Timber salvage improperly done can contribute to increased surface runoff and soil erosion (Klock 1975, Beschta et al. 1995, McIver and Starr 2001). Poorly located and improperly constructed roads, improper choice of harvesting systems, and inadequate road maintenance can contribute to erosion. Klock (1975) divided recently salvaged areas following the 1970 Entiat Fire on the Wenatchee National Forest, north central Washington, into undisturbed, slightly disturbed, and severely disturbed soil categories. He found that tractor skidding severely disturbed 37% of the tractor logged area; full suspension skyline yarding, 2.8% of the skyline logged area; and helicopter yarding, 0.7% of the helicopter logged area.

On slopes less than 30%, with a properly prepared salvage harvest plan, skid trails could be limited to about 10% of the area and treated after use to control runoff and erosion. Preliminary results from an eastern Oregon study of carefully planned salvage logging operations with ground-based machines are encouraging. Although some soil disturbance was observed after the operations, little or no sediment left the harvest units and the reburn hazard of the harvest units was estimated to be either reduced or unchanged (USDA Forest Service 2002).

Any increased watershed effects would be temporary and are dwarfed by the magnitude of the recent fire event. Extreme rates of soil erosion have been observed following major wildfires in the Pacific Northwest, including the 1970 Entiat Fire, where annual sediment losses in an unlogged watershed were 6 times annual pre-fire sediment losses in the first year and 58 times pre-fire losses in the second year during an unusually heavy precipitation year (Helvey

1980). Seven years later, annual sediment losses were still more than four times the pre-fire average.

The Forest Service Pacific Southwest Region has developed the Equivalent Roaded Area (ERA) Method as a way to compare alternative forest treatments, including severe wildfire on cumulative watershed effects (USDA Forest Service 1988, Carlson and Christiansen, 1993, McGurk and Fong 1995). The ERA method has been used in NEPA documents by national forest managers in both Oregon and California. With the ERA method, the clearing of an acre of new road surface is given a rating of 1.0 and other forest activities are given a rating between 0 and 1.0. The occurrence of a severe wildfire is given a rating of 0.3. Thus, in the ERA rating system, temporary watershed effects of severely burning 300,000 acres of forest is equivalent to the effects of clearing 90,000 acres for roads. To put this into perspective, the Biscuit area currently has about 500 miles of road occupying less than 2,000 acres. Of course, the wildfire effects are temporary, and the road effects may not be unless the roads are removed, but the comparison is clear. The natural watershed effects from the Biscuit fire are likely to be huge compared with road and timber salvage effects.

Planning and possibilities

To minimize soil disturbance while permitting maximum economic recovery of salvageable timber, a detailed harvest plan will need to be prepared, but some generalizations can be made.

Accessibility

Access to the fire-killed timber across the burn varies with land allocation (Figure 6). In total, approximately 50% of the fire-killed timber in Biscuit is within 2 miles of existing roads (Table 3). We consider 2 miles as an estimate of the maximum practical distance for salvage by helicopter if additional roads are not constructed. Thus, almost all the fire-killed timber volume within the Matrix Lands is accessible, and about 60% of the Administratively Withdrawn Areas and 80% of the Late Successional Reserves (LSRs) are accessible. Access to the Kalmiopsis Wilderness Area is marginal and not legally available to motorized machines.

Figure 6. Road access exists in much of the Matrix and some of the Administratively Withdrawn and Late Successional Reserves. (Photo by J. Sessions, April 2003)

Harvesting systems

Ground-based methods (rubber-tired and tracked skidders) are normally used where slopes are accessible and less than 30%, and cable systems (skylines) are used where slopes are greater than 30%. Ground-based systems are not physically limited in the distance they can operate from roads, but like all harvesting systems, costs increase with distance. Cable systems, depending upon terrain conditions, are physically limited to about one-half mile or less. At longer distances on steep terrain, helicopters (Figure 7) must be used or additional roads must be constructed. Economically feasible transport distance is limited by the value of the timber. If trees of mixed sizes and values are extracted, the maximum economic distance for helicopters is probably about 2 miles. If only the most valuable logs are removed, the maximum economic distance increases. Giles and Marsh (1994) reported that logs from fire-killed trees were flown as far as 4 miles on the Slater Creek Salvage Sale following the 1992 Foot Hills Wildfire on the

Boise National Forest. Since costs increase as the transport distance increases for all harvesting systems, the construction of temporary roads can reduce overall transport costs including road construction and decommissioning costs.

Figure 7. Timber salvage by helicopter. (TTTT Forestry Pictures www.foresters.org/photos/helicopter.htm accessed July 4, 2003).

As a rough comparison between skidding methods at longer distances, cost of ground skidding increases about $15 per additional ton-mile (1 ton-mile = 1 ton of wood transported one mile) and cost of helicopter yarding increases about $30 per additional ton-mile. These costs do not consider road development, felling, hooking, unhooking, loading, and truck transport.

Conversion of dollars per ton-mile to dollars per thousand board feet per mile depends upon log weight per board foot. Log weight per board foot can greatly influence profitability. It varies between 8–14 pounds per board foot and is affected by species, log length, log diameter, and log position within the tree.

Helicopter logging, although more expensive, would permit immediate salvage without additional roads and with little soil disturbance. There is sufficient helicopter logging capacity in Oregon to deliver more than 2 million board feet per day. At an estimated stumpage value of $100 per thousand board feet of salvage, one billion board feet of salvage by helicopter would recover $100 million of stumpage value. Salvage by ground-based and cable systems would return higher stumpage values, but helicopters have the significant advantage of minimizing disturbance (Klock 1975).

Harvest operations also present opportunities for postfire erosion reduction. An evaluation of postfire rehabilitation treatments indicates that logs left parallel to the ground contours (contour felling) show promise as a relatively effective erosion control measure, particularly where initial post-fire erosion is expected to be high (Robichaud et al. 2000).

Processing capacity

Markets for salvaged timber depend on quality, quantity, and price. The processing capability in the southern Oregon area (Eugene and south) is approximately 2.75 billion board feet per year (personal communication, Paul Ehinger, 2003). Additional processing centers exist in northern California. Until recently, one of the closest mills (Rough and Ready Lumber, near Cave Junction) processed 50 million board feet per year. It is now undergoing management restructuring, at least partly attributable to a lack of available timber.

Past employment multipliers for logging and processing, including the supporting services, are in the range of 8–10 persons per million board feet. The actual effect on employment would depend on whether fire-killed timber is substituted for green timber or added to the green timber harvest. In the current forest products market, substitution would probably be more likely.

Logging capacity should not be a problem, particularly if substitution of dead for green timber predominates. In addition, Oregon is the home of most of the helicopter logging and helicopter fire suppression capacity in North America. Much of this logging capacity is idle with the slowdown of federal harvests, and increased utilization also would strengthen the ability to retain this capacity for fire suppression when it is needed.

Sound, science-based strategy

Given the immense number of fire-killed trees, a location-specific strategy must be developed if timber salvage is to be undertaken. One strategy may be to establish a salvage program that recovers value while minimizing impact on other resources. This would necessitate the consideration of rules that recognize

- erosion control, including contour felling
- sensitive areas including steep slopes and exposed soils
- stream protection
- protecting key wildlife sites
- log value, yarding distance and method
- loss in salvage value over time
- regeneration activities and future access
- dead wood for wildlife and streams
- probable fire-stressed tree death from insect attack
- potential fire-risk from dead trees and down wood
- future stand-maintenance activities
- public involvement.

Alternative timber-sale preparation procedures could also be considered. Typical timber sale procedures now take up to 2 years. For green timber sales, this time investment may be reasonable given the costs and benefits of the proposed actions. In timber salvage, however, the costs of delay are extreme. Green timber may increase 2%-6% in volume and value over the 2-year timber-sale preparation period, but fire-killed trees will lose more than 40% of their value during the same period, and delays in subsequent forest regeneration will further increase costs (Figure 8).

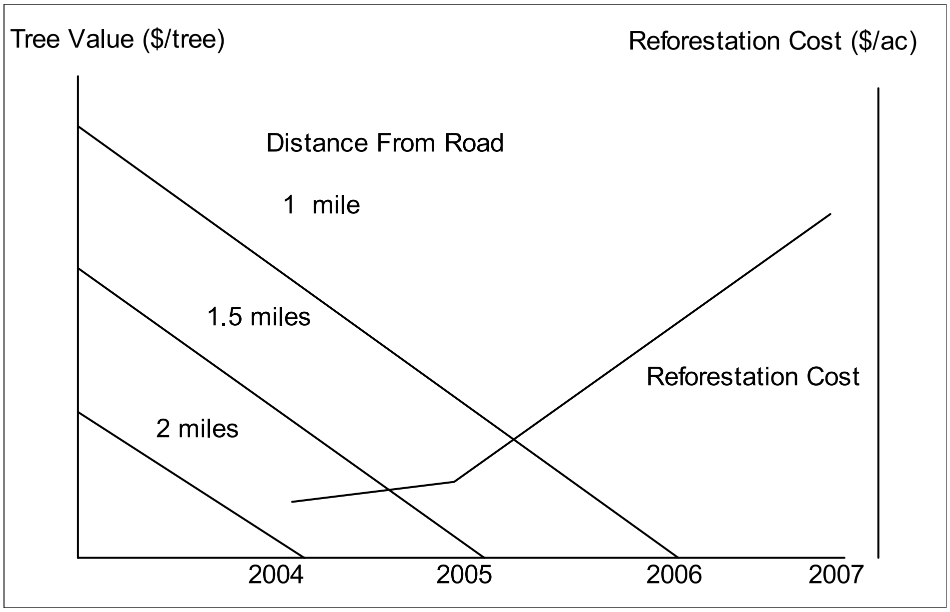

Figure 8. Average salvage value of fire-killed trees as a function of distance from road and year, using helicopter logging, and cost of reforestation.

Alternatives such as “end-result contracting” tested by the BLM offer significant time savings. Marginal cost timber pricing to encourage salvage at longer distances from roads could also be considered.

Conclusions

- The Biscuit Fire killed conifers containing about 3.6 billion board feet; up to 2.0 billion board feet of this wood volume is economically salvageable. The stumpage value of fire-killed timber immediately after the fire exceeded the combined cost of the Biscuit Fire suppression and prompt regeneration costs.
- The value of this salvageable fire-killed timber is rapidly declining due to wood deterioration. We estimate a 22% loss in the first year with only the butt logs of the largest and most resistant trees retaining value after 5 years.
- Additional soil erosion from timber salvage will be small compared to the magnitude of the natural erosion from the burned area.
- Timber salvage of fire-killed timber will speed forest recovery through removal of hazard trees that impede aerial forest maintenance operations, reduce the probability of wildfire, and make future fires more controllable through removal of hazard trees and reduction of large log

fuels. Salvage of dead trees in areas near unburned forest would reduce future fire intensity and make fire suppression easier reducing fire risk to adjacent areas. Salvage logging would certainly make fire control easier should another fire follow within the next two to three decades.

Closing Comments

The NWFP (FEMAT 1993, Tuchmann et al. 1996) attempts to protect and perpetuate mature, late successional to old-growth forest to emphasize their associated biological and ecological diversity. The use of Late Successional Reserves has resulted in very little management to create conditions that would provide some degree of resiliency to fire in dry southwestern Oregon forests. The statutory and administrative guidelines of the NWFP are largely silent on what to do after major disturbances. The chairman of the committee that prepared the NWFP (Jack Ward Thomas letter and draft report, March 11, 2003) states that, as originally proposed, the plan anticipated a dynamic—in contrast to a static (or no action)—strategy on severely damaged areas, such as those affected by the Biscuit Fire. However, inaction has been the norm following most recent fires in the Northwest.

In a related vein, Mealey and Thomas (2002) point out the interagency conflicts between regulatory agencies (U.S. Fish & Wildlife Service or FWS, National Marine Fisheries Service) and land management agencies (Forest Service, BLM). The views of regulatory agencies tend to be precautionary, short-term, and risk averse. Land management agencies, on the other hand, tend to take a longer view—accept some short-term adverse consequences in order to attain long-term ecological objectives. A departure from this source of conflict may come from an interagency memo of December 10, 2002 (FWS, NOAA–Subject: Evaluating the Net Benefit of Hazardous Fuels Treatments Projects) which encourages the two agencies, in their regulatory role, to address the relative risk question with the management agencies.

For the public and for policy makers, the essential question created by the Biscuit Fire is this: do we let natural processes deliver whatever vegetation and habitats will follow fires in Late Successional Reserves, or, if nature is unlikely to yield the desired future conditions, do we hasten the return of forests to preferred ecological conditions through management interventions?

Lessons from other recent catastrophic events

Lessons can be learned from other catastrophic events involving forests, including large fires, tornados, hurricanes, and volcanic eruptions. Salvage from another large fire is in progress on the White Mountain Apache Reservation. The Rodeo-Chediski Fire started on June 18, 2002, three weeks before the Biscuit Fire, and burned 462,000 acres, of which 276,000 acres were on the White Mountain Apache Reservation. Ponderosa pine, the primary burned species, deteriorates quickly, first by stain and then by sapwood decay. By November 2002, timber sale plans had been developed by the Bureau of Indian Affairs, an Environmental Analysis report had been completed, contracts had been awarded, and the first logs were being salvaged. Since then, up to 500 thousand board feet per day have been salvaged, much of it by helicopter, with logs being transported by rail as far as northern California. The accelerated administrative process compressed the normal 2-year timber-sale preparation process into 4 months. Thirty-one years earlier, the Corizo Fire had burned entirely inside the perimeter of the later Rodeo-Chediski Fire. In areas where fire-killed trees had been removed following the Corizo Fire, fire intensity during the 2002 burn was much lower than on areas where fire-killed trees had been left. Timber salvage from the same fire on the adjacent Apache-Sitgreaves National Forest is under appeal; the economic value of that timber has largely been lost, as well as the opportunity to economically remove the fire-killed trees that will form the heavy fuels for the next wildfire. (John Philbin, BIA regional forester, personal communication, May 14, 2003).

Accelerated salvage processes, although much smaller in area, have been initiated recently on two national forests in other regions following tornado damage (Mark Twain National Forest, Missouri) and hurricane damage (Davy Crockett National Forest, Texas). In these cases, concerns over public safety and threat to endangered species habitat were the basis for a Council of Environmental Quality (CEQ) exemption from normal NEPA requirements. Both recognized the need for urgency in decision-making. In the case of the Tornado Salvage, less than 4 months elapsed between the storm on April 24, 2002, and the initiation of the first salvage logging in early August.

Private owners routinely salvage and reforest after catastrophic events. Following the May 1980 eruption at Mt. St. Helens, Weyerhaeuser Company initiated salvage as soon as it was safe to work in the blast zone, recovered over 0.8 billion board feet in less than 2 years, replanted, and now has a forest of trees 50+ feet tall and a thriving wildlife community.

Can decision making be accelerated?

The relatively short time between burn and salvage on the Rodeo-Chediski Fire was due to an environmental analysis rapidly prepared by Bureau of Indian Affairs and the White Mountain Apache Tribe. It was based primarily on social and economic considerations. Project Tornado on the Mark Twain National Forest received a CEQ exemption and began salvage in less than 4 months. The Texas salvage operation was granted a CEQ exemption based on health and safety, plus some consideration for rare and endangered species.

We pose this question to society and forest managers, “What would be the basis for speeding up consideration of reforestation, salvage, fire and insect hazard reduction on Biscuit?”

Figure 9. Northern spotted owl, an endangered species that requires mature forest habitat. (Photo by John and Karen Hollingsworth, courtesy of the U.S. Fish and Wildlife Service.)

Health and safety are important, though not as prominent as in the Missouri and Texas projects, since people and property are further removed from the fire boundaries. Endangered species are also a consideration since reforestation efforts will hasten the return of suitable habitat for some species (Figure 9). Economic and social concerns are substantial in southwest

Oregon as they were in the Arizona fire.

Can the agency speed up the resolution of these questions? Is an accelerated decision process for selecting the future course for Biscuit ecosystems best for the land or the people affected by the land? Will the land or the people affected by it be better served by letting nature take its course or making strategic investments to influence to course of future ecosystems? Will society or Biscuit managers be able to capitalize on this once-in-a-generation opportunity to learn the consequences of inaction for future forests versus making the action choice?

Time is not neutral. If society or agency managers do not choose to expedite post-Biscuit decision making so that restoration action can begin by 2004 and end by 2006 or 2007, then nature alone will determine the future habitats in 200,000 to 400,000 acres of burned federal forests. These future Biscuit-burned landscapes, regardless of congressional or administrative intent, will likely be dominated by cycles of shrubs and fires until the climate returns to cooler and wetter conditions.

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